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terranean cavity with great velocity. A, B, C, D indicate the path of a moving fountain, which always terminated at D, the most violent point. A is the place of "Old Faithful," erupting at the intervals to be specified, liberating large volumes of gas or steam. At X there was a bubbling of similar character, always accompanying A to the right of Z, where the lava was constantly disappearing.

The second diagram (Fig. 4) indicates graphically the number of eruptions in periods of ten minutes for nine hours upon February 15, and eight hours the following day. The maximum number was 21 and the minimum 12, with the average of 16+ and 16.7+.

It is the first time that any attempt has been made to record the number and intensity of these outbursts, and the diagram may illustrate one of the class of observations that will be made when the Seismological Observatory shall be established at this locality.

RAILROADS IN ASIA MINOR.

BY

ELLSWORTH HUNTINGTON.

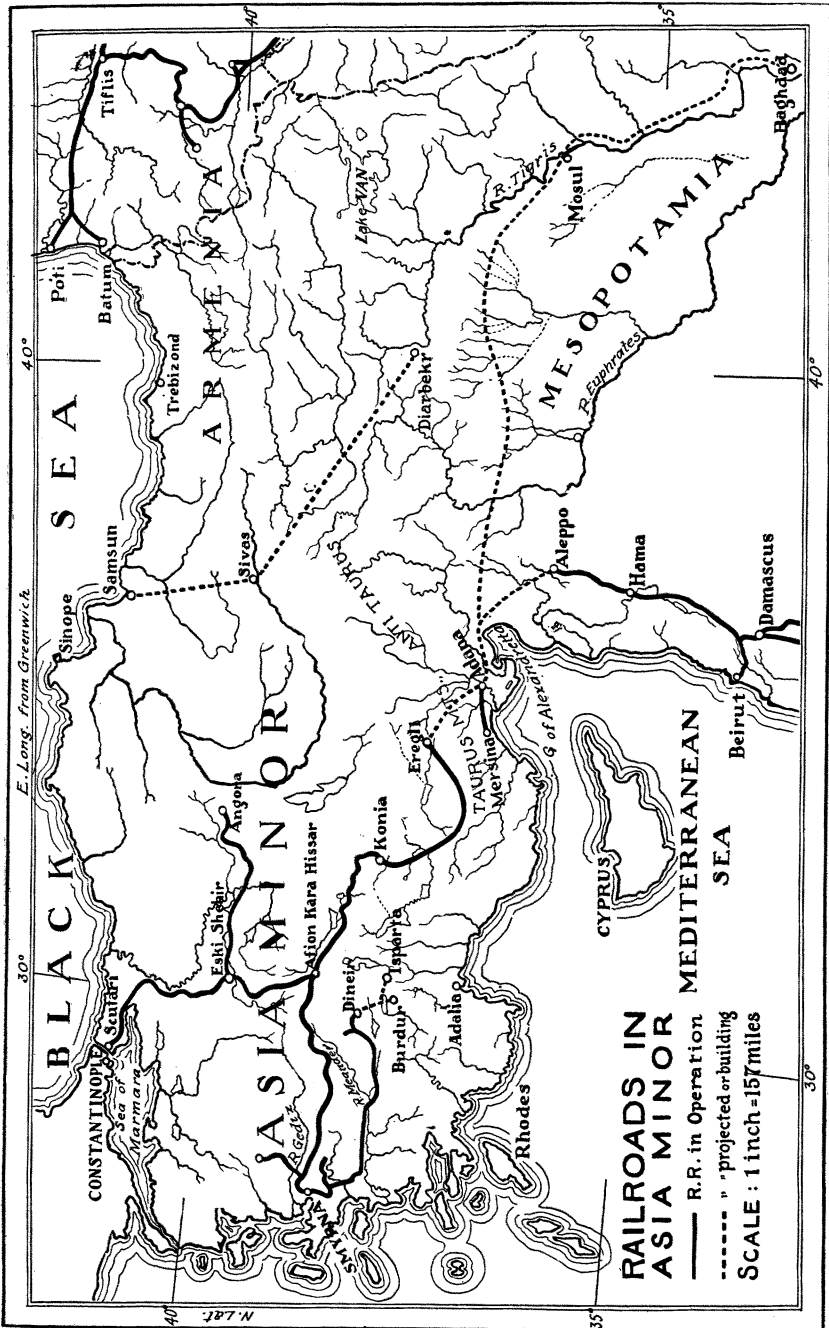
The year 1909 has been characterized by an important renewal of railroad building in Asia Minor. In addition to far-reaching plans, which are as yet only under discussion, there are other plans which are in actual process of accomplishment. The plans under discussion provide for a railroad which shall start on the Black Sea, presumably at Samsun, and go southward across the central plateau to Sivas, about 4,500 feet above the sea, and then southeast to Diarbekr at the southern foot of the plateau, whence it will continue into Mesopotamia to join the long-talked-of Baghdad Railway. From Sivas branches will run east and west along the plateau. The special object in view is to reach the rich mines of copper, silver and other minerals which might be worked to great advantage if transportation facilities were provided. An American company has offered to finance the undertaking with no other guarantee than the right to work all the mines along the zone within easy reach of the proposed railroad.

Far more definite than the plans mentioned above is the actual work now being accomplished upon the Baghdad and Dineir Railways. At the present day three railroads, financed by German, French and English companies, respectively, run up the long east

and west valleys which divide western Asia Minor into huge projecting fingers of mountains. The original German road starts at Scutari, opposite Constantinople, and follows the Sangarius River more or less closely eastward and southeastward for 300 miles to Angora. The French road runs almost due east from Smyrna up the Gediz River for 200 miles to Afion Kara Hissar; and the English road, also starting from Smyrna, goes south along the seacoast to Ephesus and then east up the Meander River nearly 200 miles to Dineir. All three roads come to an end on the barren plateau of Asia Minor at an elevation of about 3,000 feet. In addition to these, another line, the finely equipped Baghdad Railway, leaves the old northern line, half way from Constantinople to Angora, at Eski Shehir where the plateau is first reached, and runs southward 75 miles across the plateau to Afion Kara Hissar, where it joins the road from Smyrna up the Gediz Chai. Then it runs southeastward 300 miles farther to a point a little beyond Eregli and comes to an end at the northern base of the high mountains which border the plateau and shut it off from the northeast corner of the Mediterranean.

For years the Baghdad Railway has had no connection with the French line to Smyrna. The two stations at Afion Kara Hissar were a mile and a half apart, and the government would not allow them to be connected ostensibly because the building of the extra two kilometers of line would add a trifle to the kilometeric guarantee paid by the state. Five years ago the railroads undertook to build the connecting link without permission. They built it and the line was promptly torn up by the government. So for five years more all traffic from the interior of the plateau to Smyrna was subjected to the great delay and expense of transfer by wagons at Kara Hissar. Under the new régime the link has once more been built, and since the spring of 1909 has been in operation. The real cause of the former opposition of the government was probably the desire to concentrate all trade at Constantinople. Smyrna is the natural outlet for the greater part of Asia Minor, and there can be no doubt that the new arrangement will increase its trade at the expense of Constantinople. The recent growth of Smyrna to a size of nearly 350,000, as it is now estimated, shows the strength of its opposition commercially.

For six or seven years the Baghdad Railway has waited at the edge of the plateau. At last it is about to cross the mountains and drop down to the warm, fertile Cilician Plain at Adana close to the northeast corner of the Mediterranean Sea. Already surveys have been completed across the Taurus range, which here borders the



plateau, and the building of the track will begin at once. The highest point reached is about 5,000 feet above sea level. From there the road will run down the Chakit River, a branch of the Seihun or ancient Sarus which flows through Adana. The famous Cilician Gates, through which Darius, Xenophon, Alexander and other conquerors have passed, will be left about five miles to the west of the line. From the pass over the Taurus to the edge of the Cilician plain there is a descent of nearly 5,000 feet in a distance of about 70 miles as measured along the Chakit River without reference to the minor windings. Part of the distance is through an almost inaccessible gorge. Here there is a fall of over 2,000 feet in scarcely 20 miles; so that the average grade for the entire distance is one in fifty. Numerous tunnels will be required. German and Greek engineers are now engaged in laying out the route which bristles with difficulties.

At Adana the Baghdad Railway will connect with the short line some forty miles long which traverses the Cilician plain in a south-westerly direction through Tarsus to the seacoast at Mersina. The main line will not here touch the seacoast, but will go on eastward to get around the northeast corner of the Mediterranean. As yet it has not been finally decided whether the line shall go directly across the Giaour Dag Mountain of the Amanus range and so by the shortest route to Aleppo, or whether it shall skirt the coast for forty miles to the small port of Alexandretta and then cross the mountains to Aleppo. Neither route is easy. The present wagon road from Alexandretta to Aleppo crosses a pass 2,000 feet high within ten miles of Alexandretta. The difficulty of surmounting this pass is the reason why the engineers are searching for an easier way which shall avoid Alexandretta. Altogether the section of the Baghdad Railway, from the Anatolian plateau to the great Syrian plain at Aleppo, involves engineering feats of the first class. According to the statements of the engineer in charge of the final surveys it is more difficult than any railroad in Europe except that of the Simplon in Switzerland.

It will probably be five years, and possibly more, before the Baghdad Railway will be completed as far as Aleppo. It will there connect with the Mecca Railway, which already is in operation, through Damascus to the holy city of Medina and will soon reach Mecca.

The Turkish railway project which is at present nearest completion is the extension of the nominally English railroad up the Meander R. beyond Dineir. The railroad reached Dineir a dozen or more years ago. Now it is to be extended along two branches, one to Buldur, forty miles to the south, and the other to Isparta, an equal

distance to the southeast. Both these places are towns of 20,000 or 25,000 people, famous for the attar of roses produced in their rose gardens. Already the railroad is almost completed to Kechi Borlu, the halfway station, whence the two branches diverge. The first seven miles from Dineir consists of a great curve seven miles in length, which brings the line back to a place only a little over a mile from the town, but 700 feet higher than the starting point. Here a limestone ridge is pierced by a tunnel 750 feet long and the road comes out upon a smooth plain famous in mythology as the place where Apollo flayed Marsyas after defeating him in playing the lyre. Thence for 14 miles the line to Kechi Borlu is easy. It is expected that the lines to both Isparta and Buldur will be completed within two years. The Isparta line will be continued twenty miles the following year to the picturesque town of Egerdir upon the beautiful lake of the same name. The lake lies near the southern edge of the Anatolian plateau. From it a valley leads southward to Adalia, about 100 miles away on the southern coast of Asia Minor. Down this valley a railroad will doubtless some day be built, but not at once, for there is a tremendous unexplored canyon fifteen or twenty miles in length where the valley crosses the edge of the plateau.

When the lines now under construction are completed Turkey will have a continuous railroad system nearly 2,000 miles long from the political capital on the Bosphorus to the religious capital in distant Arabia. After leaving the vicinity of Constantinople the railway will not touch the seacoast at any point except perhaps Alexandretta. The configuration of the mountains along the Syrian coast and of the high plateau of Anatolia forbid this. There will, however, be two outlets to the sea in Syria, namely the lines from Damascus to Haifa, the mediaeval Acre, and to Beirut. There will be another outlet in the Cilician plain, and still a fourth at the western end of the Anatolian plateau to Smyrna, the commercial capital of Asia Minor and almost of Turkey. In addition to this there will be the Dineir Railroad with half a dozen branches, all feeding into Smyrna, and various branches of the main line from Smyrna to Afion Kara Hissar. Altogether the western and southern parts of the Turkish Empire will be comparatively well supplied with railroads. As the facts given above well show, railroad construction in all parts of the Empire except the southern plains is full of difficulty by reason of the prevalence of mountains. The only place where mountains do not oppose constant obstacles to railroad building is the central part of the plateau which is either so dry or so high and cold that it possesses very little wealth and few inhabitants. Altogether, in

view of the physical nature of the country, the sparsity of population, and the nature of the government, it is remarkable not that Turkey has so few, but that she has so many railroads.

CORRESPONDENCE.

SOME OF THE DIFFICULTIES OF PRECISION IN CIRCUMPOLAR INSTRUMENTAL OBSERVATIONS.*

TO THE AMERICAN GEOGRAPHICAL SOCIETY:—All navigators, even in well-known seas, know the liability to serious error in establishing their positions upon the best charts by what is known as "Dead Reckoning," particularly when for days they have been groping in fogs, driven by gales, tossed by heavy seas and suffering from effects of abnormal weather.

Upon approaching dangerous coasts the careful navigator makes large safety allowances for the uncertainties attending such calculations which depend so largely upon individual judgment as to the strength and direction of the invisible forces, which are constantly at work and so frequently drag the ship to its destruction. Drift or leeway, the force and direction of capricious currents, uncertain variations of compass, local deviations, errors in marking the speed of the ship, possible oversight of men, all combined, make dead reckoning only an approximation of the true position of the navigator in any part of the ocean.

These elements of error are enormously exaggerated in the Arctic seas, and, if Dr. Cook's and Commander Peary's declared positions should depend upon dead reckoning alone, they might have extreme difficulty in proving to the satisfaction of competent judges that either of them had reached their objective. Without the corroborative evidence of astronomical observations, their statements of success would be regarded as mainly guess work. Their "log books" could be written, and courses and distances plotted on charts in New York, without either of them doing more than disappearing from public view for the time covered by their records.

Throwing aside the dead reckoning, except so far as it adds to the interest of their narrations, and may be corroborative in some measure of their progress, it would seem that observations of the sun's altitude, both for latitude and longitude, must be the only means of fixing, even with approximate certainty, the position of the observer in circumpolar regions. The natural horizon, broken by ice hummocks, obscured by vapour, radiation and mirage, gives but an uncertain point of contact with the sun's lower limb, and an artificial horizon is therefore a necessary part of the equipment.

Artificial horizons are of two descriptions—one of mercury and one a mirror. The former, when the temperature is at or below the freezing point, must be warmed artificially, and the latter levelled by spirit levels, adjustment screws, and be placed upon a firm, solid base. Unless the spirit levels are warmed in the temperatures recorded, the spirits would freeze and levelling by them would become impracticable, however quickly applied. The mirror horizon on an un-

* Captain John S. Barnes, who makes this communication to the Society, was formerly of the United States Navy, and as a navigator of sailing ships, he was, for many years, charged with the responsibility of fixing with accuracy the hourly position of a ship upon long voyages in varying climates.